MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022/2023

DME5136 – Thermodynamics

(Diploma in Mechanical Engineering)

6 JULY 2023
2.30 p.m. – 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 5 pages including the cover page with 4 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1 (25 marks)

(a) A piston-cylinder device contains 0.3 m^3 of 4 kg of water at 180 °C (State 1). It then undergoes an isobaric expansion process to State 2, where the temperature increases to 400 °C.

(i) Determine the values of the specific volume at State 1. [2 marks]
(ii) Determine the pressure in the piston-cylinder. [2 marks]
(iii) Determine the values of the specific volume at State 2. [2 marks]

(iv) Sketch the process on a *T-v* diagram with respect to the saturated liquid and saturated vapor lines. Label both states and the path. Use arrow to indicate the direction of the process. [5 marks]

(v) Sketch the process on a *P-v* diagram with respect to the saturated liquid and saturated vapor lines. Label both states and the path. Use arrow to indicate the direction of the process. [4 marks]

(b) A motorist equips his automobile tires with a relief-type valve so that the pressure inside the tire will never exceed 220 kPa (gauge). He starts the trip with a pressure of 200 kPa (gauge) and a temperature of 23°C in the tires. During the long drive the temperature of the air in the tires reaches 83°C. Each tire contains 0.11 kg of air. Determine:

(i) the mass of air escaping each tire, [6 marks]
(ii) the pressure of the air inside the tire when the temperature returns to 23°C. [4 marks]

Question 2 (25 marks)

(a) Steam flows steadily through an adiabatic turbine shown in Figure Q2a. The inlet conditions of the steam are 6 MPa, 400°C, and 80 m/s, and the exit conditions are 40 kPa, 92 percent quality, and 50 m/s. The mass flow rate of the steam is 20 kg/s. Determine

(i) the change in kinetic energy, [2 marks]
(ii) the power output, and [8 marks]
(iii) the turbine inlet area. [4 marks]

Continued ...

(b) Air at 300 K and 100 kPa steadily flows into a hair dryer shown in Figure Q2b having electrical work input of 1500 W. Because of the size of the air intake, the inlet velocity of the air is negligible. The air temperature and velocity at the hair dryer exit are 80°C and 21 m/s, respectively. The flow process is both constant pressure and adiabatic. Assume air has constant specific heats evaluated at 300 K.

(i) Determine the air mass flow rate into the hair dryer, in kg/s. [7 marks]
(ii) Determine the air volume flow rate at the hair dryer exit, in m^3/s. [4 marks]

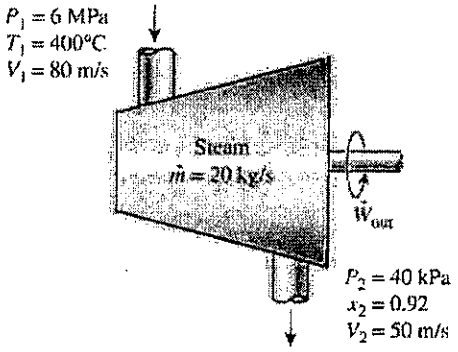

Figure Q2a

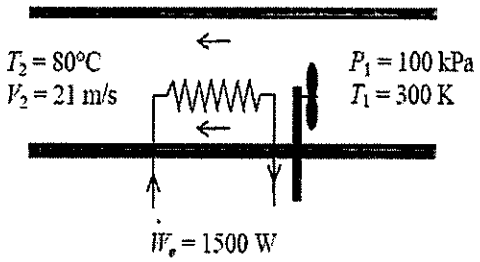

Figure Q2b

Question 3 (25 marks)

(a) What is the difference between a heat engine and a refrigerator? Sketch the schematic diagram for both systems. [8 marks]

(b) The following heat engines produce power of 95,000 kW. Determine in each case the rates at which heat is absorbed from the hot reservoir and discarded to the cold reservoir.

(i) A Carrot engine operates between heat reservoirs at 750 K and 300 K.
(ii) A practical engine operates between the same heat reservoirs but with a thermal efficiency of 0.35. [10 marks]

(c) Determine if a tray of ice cubes could remain frozen when placed in a food freezer having a COP of 9, operating in a room where the temperature is 32 °C. [7 marks]

Continued ...

Question 4 (25 marks)

(a) Consider two engines in Figure Q4.

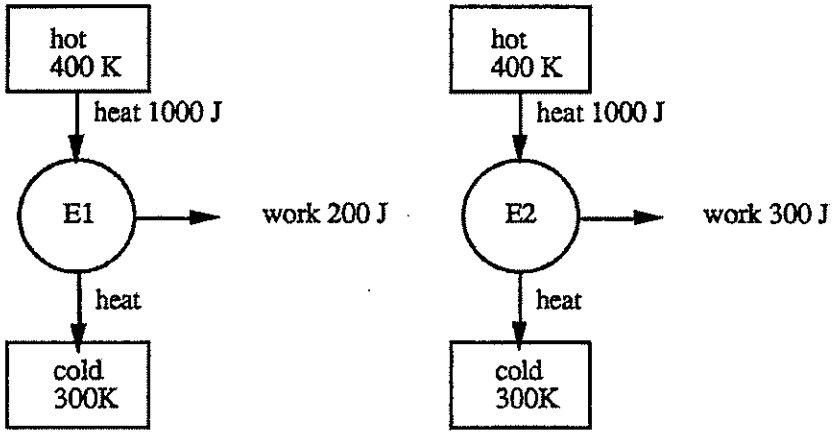

Figure Q4

The energies quoted are for one cycle of operation of the engines.
For both engines:-

(i) Calculate the heat lost to the cold reservoir. [1 mark]

(ii) Calculate the entropy changes on the hot reservoir, the cold reservoir and the engine. [4 marks]

(iii)Calculate the Carnot thermal efficiency. [2 marks]

(iv)Can the engine operate? [2 marks]

(v) Justify your answer in iv) by comparing its total entropy changes. [2 marks]

(vi)Justify your answer in iv) by comparing its thermal efficiency. [2 marks]

(b) Two kilograms of saturated water vapor at 600 kPa are contained in a piston-cylinder device. The water expands adiabatically until the pressure is 100 kPa and is said to produce 700 kJ of work output.

(i) Determine the entropy change of the water, in kJ/kg-K.

(ii) Is this process realistic? Using the *T-s* diagram for the process and the concepts of second law, support your answer. [12 marks]

Continued ...

Appendix

Uniform State Uniform Flow (Unsteady Flow)

Continuity:

$$(m_2 - m_1) = \sum_i m_i - \sum_e m_e$$

First Law:

$$\sum_i m_i\left(h_i + \frac{V_i^2}{2} + gZ_i\right) + \sum_e m_e\left(h_e + \frac{V_e^2}{2} + gZ_e\right) + Q_i - Q_e + W_i - W_e$$
$$= m_2\left(h_2 + \frac{V_2^2}{2} + gZ_2\right) - m_1\left(h_1 + \frac{V_1^2}{2} + gZ_1\right)$$

Second Law:

$$m_2 s_2 - m_1 s_1 = \sum_i m_i s_i - \sum_e m_e s_e + \int_0^t \frac{\dot{Q}_{cv}}{T} dt + {}_1S_{2\,gen}$$

Ideal Gas

Ideal Gas Equations of State

$$Pv = RT$$
$$dh = C_p dT$$
$$du = C_v dT$$

Specific Heats and Ideal Gas Constants

$$C_p - C_v = R$$
$$\frac{C_p}{C_v} = k$$

Entropy Relationships

$$s_2 - s_1 = C_v \ln\frac{T_2}{T_1} + R\ln\frac{v_2}{v_1} \quad \text{if constant } C_v$$
$$= C_p \ln\frac{T_2}{T_1} - R\ln\frac{P_2}{P_1} \quad \text{if constant } C_p$$
$$= s^0_{T_2} - s^0_{T_1} - R\ln\frac{P_2}{P_1} \quad \text{otherwise}$$

For polytropic process

$$PV^n = c$$
$${}_1W_2 = \frac{P_2V_2 - P_1V_1}{1-n} \quad n \neq 1$$
$$= P_1V_1 \ln\frac{V_2}{V_1} \quad n = 1$$

End of Paper